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Feasibility of Using the AN/PVS-14 Monocular Night Vision Device for Pilotage

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Aircrew Health and Performance Division
and
Flight Systems Branch

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The AN/PVS-14 Monocular Night Vision Device (MNVD) high performance image intensification system was designed for ground use. During a USAARL optical and visual evaluation of the MNVD, the authors noted that the user could fuse the intensified image with the unaided or nondisplay viewing eye. The fused images from the right and left eyes provided some color and depth perception under certain night lighting conditions and allowed the unaided eye to remain dark adapted. This assessment explored the potential use of the MNVD for pilotage using two experienced night vision goggle (NVG) UH-60 pilots and two experienced AH-64 pilots, who also used the helmet display unit (HDU) with symbology and thermal imagery. The conclusions from this initial concept assessment are the following: (1) The binocular standard Aviator's Night Vision Imaging System (OMNI II ANVIS) would be preferred overall to the single tube AN/PVS-14 for pilotage. (2). Both UH-60 pilots reported difficulty in judging distances and closure rates, while the AH-64 pilots rated the MNVD slightly better for depth perception than standard ANVIS. All four pilots reported some eyestrain or discomfort, which increased with no moon illumination.

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(3) Under starlight conditions, resolution, depth perception, and vision outside the cockpit were ranked as much less than the standard ANVIS by the UH-60 pilots, although the single tube PVS-14 has much greater gain and resolution than each tube in the standard binocular OMNI II ANVIS. On the other hand, the AH-64 pilots rated the MNVD better than standard ANVIS under the high and low light conditions for the same characteristics. Both UH-60 pilots thought that additional training with the MNVD would improve the comfort level, but probably not the performance under starlight conditions. Both UH-60 pilots also flew with the OMNI IV ANVIS and reported significant improvements over the standard ANVIS for resolution and low light performance as previously reported in the original OMNI IV assessment.

The Apache pilots evaluated the concept of using the MNVD with the Helmet Display Unit (HDU) both with and without Forward Looking Infrared (FLIR) imagery. The pilots reported favorably with the image intensified MNVD mounted in front of the left eye and the flight symbology provided to the right eye from the HDU. However, the apparent unaided vision and field of view with the MNVD and HDU combination was blocked by the dark combiner over the right eye, which was not the case for the UH-60 pilots. Using the FLIR and MNVD simultaneously was both nauseating and very confusing. One of the pilots could use both systems by alternately closing one eye, but he did not consider this a viable approach or technique during typical Apache night flight operations.

All four pilots ranked the AN/PVS-14 MNVD slightly worse than the standard OMNI II binocular ANVIS overall. The Apache pilots would prefer the binocular ANVIS with injected flight symbology as currently used in the UH-60 and CH-47 aircraft. Such a system has been developed by Honeywell that would give the option of using ANVIS with symbology or the HDU with FLIR without the thermal sensor cool down delay.

Acknowledgements

The authors would like to express their appreciation for the pilots that participated in these flight assessments of the Monocular Night Vision Device (MNVD). We would also like to thank COL James Mowery, Director of Evaluation and Standardization (DES) for providing the support to this study for the AH-64 Apache evaluation, which included pilots and aircraft.

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Objective

The objective of this study was to compare the subjective impressions of the AN/PVS-14 Monocular Night Vision Device (MNVD) for pilotage in UH-60 Blackhawk and AH-64 Apache helicopters compared to the standard AN/AVS-6 aviator's night vision imaging system (ANVIS) currently in use.

Military significance

ANVIS has been used by the copilot/gunner (CPG) in the AH-64 Apache helicopter. However, the guidance is to mount either the ANVIS or the helmet display unit (HDU) on the helmet, but not both at the same time due to the combined head supported weight. However, when ANVIS is used, the CPG does not have any flight symbology. With the AN/PVS-14 mounted in front of the left eye and the HDU before the left eye, the CPG could use the MNVD for imagery and the HDU for symbology. To use only the HDU, the CPG would flip-up the MNVD and turn on the forward looking infrared (FLIR). The total head borne weight from the AN/PVS-14 and HDU mounted on the integrated helmet and display sighting system (IHADSS) (approximately 5.5 lbs.) would be similar to that from the standard ANVIS alone on the IHADSS mount with an additional improvement in the center of gravity.

The performance of the AN/PVS-14 for resolution under high illumination is much better (approximately 3000 lines) than the imaging system planned for Comanche (<1000 lines). If the MNVD can be used for pilotage, it would at least prove a back-up system for the pilot and could be a primary imaging system for the CPG.

Presently, the Civil Air Patrol does not search at night primarily due to equipment limitations. If the military has an accident at night, only the military could provide search and rescue from an airborne platform. With night vision goggles (NVGs) the number of airborne search platforms could include the Civil Air Patrol. The AN/PVS-14 with the manual gain control may be better suited for pilotage and search.

During urban missions at night by Special Operations and civilian police forces, the light levels are much higher than normal NVG operations. Having one eye with an image intensifier with manual control and an unaided eye, the MNVD user can fuse the two images, thereby potentially seeing color and having clear unobstructed near vision from the unaided eye.

Background

Since 1975, Army helicopter pilots have been using NVGs for pilotage. The first design was called the AN/PVS-5, which was developed for infantry use, but was adopted for aviation until the ANVIS AN/AVS-6 series could be developed. Both of these NVGs are *binocular* with two

tubes and have a 40 degree field of view. The AN/PVS-5 NVGs use 2nd generation technology and achieve 20/50 resolution under optimum conditions. Following the fielding of the AN/PVS-5 in the late 1980s, the ground units developed a third generation *biocular* NVG (AN/PVS-7) with a single tube that is seen by both eyes. The AVS-6 NVGs are third generation technology. The typical ANVIS currently in use was purchased prior to 1995 and has 20/40 resolution under optimum conditions. More recent image intensifier tube developments have obtained up to 20/25 resolution. The AN/PVS-14 MNVD, which has a single tube that is viewed by either the right or left eye, has the more advanced image intensifier system.

In the 1980s, the AH-64 helicopter pilots learned to use a *monocular* IHADSS for pilotage. A cathode ray tube (CRT) display of the FLIR sensor was head coupled to the HDU. The field of view of the HDU is rectangular with 40 by 30 degrees, horizontally and vertically, respectively. Resolution has been listed from 20/70 to 20/120, with the differences in vertical and horizontal resolution being a function of the number of TV lines and bandwidth. Some of the symptoms reported with the IHADSS are retinal rivalry, double vision, disorientation, and eyestrain (Behar et al, 1990). In the early development of the IHADSS, a single tube image intensifier was optically coupled to the HDU on the same eye. Although the few pilots who evaluated the optically coupled image intensifier with the HDU rated it favorably, it was never pursued.

In a study (Crowley et al., 1996), 13 pilots judged absolute and relative altitudes during an approach to landing using a binocular ANVIS, a monocular ANVIS, a monocular IHADSS at night; and with unaided unrestricted, and restricted to 40 degrees field of view, during the day. The aircraft was a modified AH-1 Cobra with a Pilot's Night Vision Sensor (PNVS). The results showed that the subjects performed poorly when asked to provide absolute altitude estimates under any condition, but were more reliable in estimating relative changes in altitude. The FLIR altitude deviations were consistently worse than the other viewing conditions and were attributed to the poor resolution and the exocentric location for the FLIR sensor in the nose of the aircraft.

In support of the Land Warrior Program for the development of the night imaging system, studies were conducted to evaluate the differences among binocular, biocular, and monocular systems. The image intensifier tubes were matched for the test goggles with maximum resolutions of 20/40. In one study, 36 participants transversed a ground course and searched for targets using the 3 different type NVGs. The results and preference favored the binocular system over the biocular and monocular NVGs (CuQlock-Knopp et al., 1996). Another study evaluated the difference between comfort between the biocular and monocular NVGs using 44 participants over a 4-hour period (CuQlock-Knopp et al., 1997). Overall, there were no differences between the two systems on the subjective assessments or preference, diopter focus settings, or significant correlation between the diopter focus settings and reported eyestrain or headaches.

Some interesting features of the MNVD were found that could be very beneficial for night flight, especially for civilian applications such as medical rescue, police activities, and search and rescue with the Civil Air Patrol (McLean, 1998a). With the MNVD, the user fused both the image seen with the unaided eye and the image from the intensifier. The unaided eye remained

dark adapted or adapted to the lighting conditions, but could see colored lights, with no effect on peripheral vision sensitivity (McLean, 1998b). Looking at the instrument panel did not require users to raise their heads as was necessary with the ANVIS. Users of the MNVD felt that they had more field of view with the unaided eye. The manual gain control with a flip type pinhole cover for the MNVD provided excellent vision just after sunset, when it was too bright for the standard ANVIS and too dark for the unaided eye. Also, the cost and weight of the single tube AN/PVS-14 were less than the cost and weight of the standard ANVIS. Figure 1 shows the ANVIS and MNVD mounted on the HGU-56/P flight helmet.

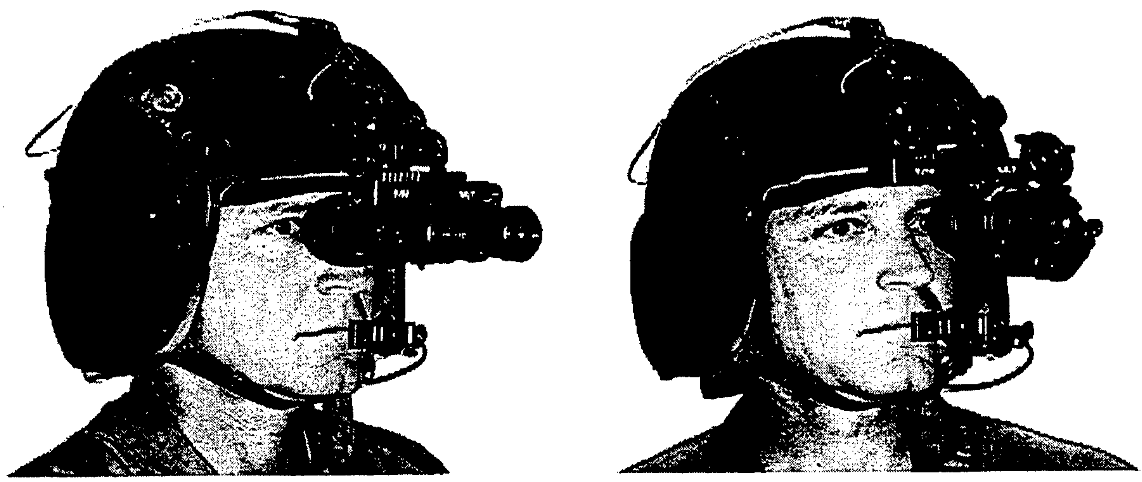

Figure 1. Binocular ANVIS (left) and monocular AN/PVS-14 MNVD (right).

Methods

Night vision goggles used in the pilot study

AN/PVS-14 MNVD

The AN/PVS-14 is a high performance OMNI IV, monocular image intensifier device. Several components of the AN/PVS-14 MNVD were modified to allow the MNVD to be mounted to an aviator helmet and to improve operations under higher light levels. The small manual gain knob could not be easily used with gloves, so a larger knob was glued to the end of the standard manual gain knob. The part of an ANVIS monocular housing that contained the purge valve and interpupillary distance (IPD) threads was epoxyed to an aluminum bracket which provided a method to attach the AN/PVS-14 to a dual IPD ANVIS pivot-and-adjustment shelf for viewing with either the right or left eye (Figure 2). For this phase, the MNVD was mounted only for left eye viewing.

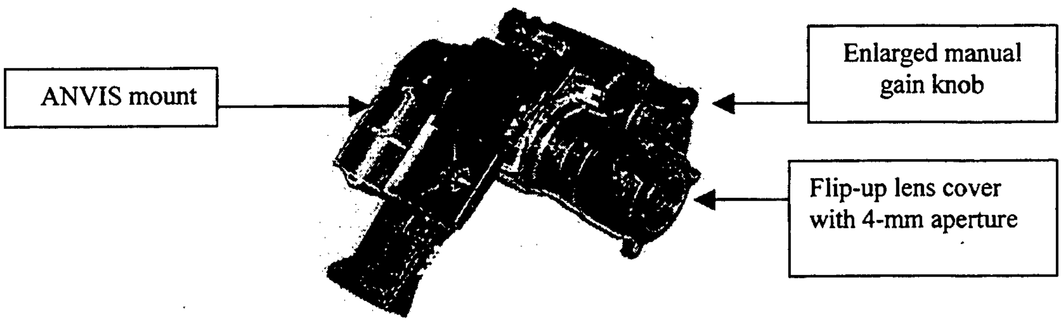

Figure 2. Modified AN/PVS-14 MNVD with ANVIS mount.

To prevent the pilot from inadvertently inducing excessive minus power in the eyepiece of the MNVD, a custom ring was fabricated to clip on the back of the MNVD eyepiece to prevent the diopter adjustment knob from being turned clockwise in the minus direction any greater than –0.37 diopters. The range for the eyepiece plus lens power was not affected (Figure 3).

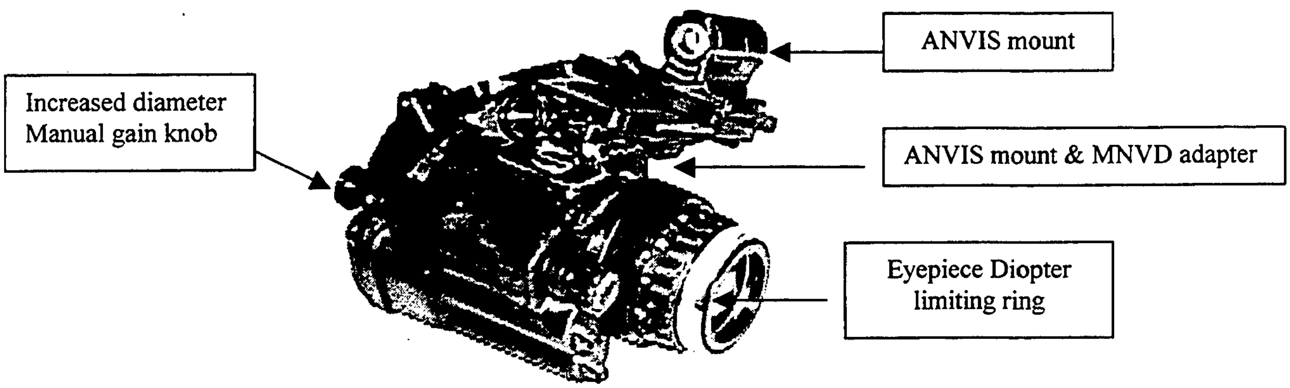

Figure 3. AN/PVS-14 modifications.

The eyepiece optics for the MNVD is the same as the 25-mm ANVIS eyepiece. This means that the geometric center of the eyepiece is not exactly the optical center of the eyepiece. The difference between the location of the geometric and optical centers was incorporated to accurately adjust the collimation or optical vertical and horizontal alignment between the right and left image channels of the ANVIS. This same method is used with the objective lenses of most binoculars for adjusting parallel alignment between the right and left channels. Usually for a monocular device, collimation is not considered important since the optical image is not fused with the natural image that is seen by the other eye. However, for the MNVD, we found that the user could and would fuse the intensified image with the unaided eye image under mesopic lighting conditions. Therefore, it was important to insure that the MNVD image did not induce excessive vertical or lateral displacement (vertical or horizontal prism).

The Night Vision Test Set (TS-3895) used for collimating binocular NVGs does not have a provision to collimate a monocular device. The collimating targets in the Test Set are not visible to the unaided eye. We therefore developed a method and device using the TS-3895 and the collimating attachment to check and adjust the residual prismatic deviations of the MNVD to minimize both vertical and base-in prism effects. We used a green LED mounted on an opaque disk with an off- set hole to illuminate the collimating rectangle in the TS-3895. The LED was connected to a pair of double AA batteries with fixed and variable resistors to adjust the light intensity (Figures 4 and 5). The MNVD eyepiece was loosened and rotated until there was no vertical or base-in (diverging) residual prism while viewing through the collimating attachment. The image intensifier tube can slightly move within the housing, so the MNVD was lightly taped on the bottom prior to the collimation adjustment.

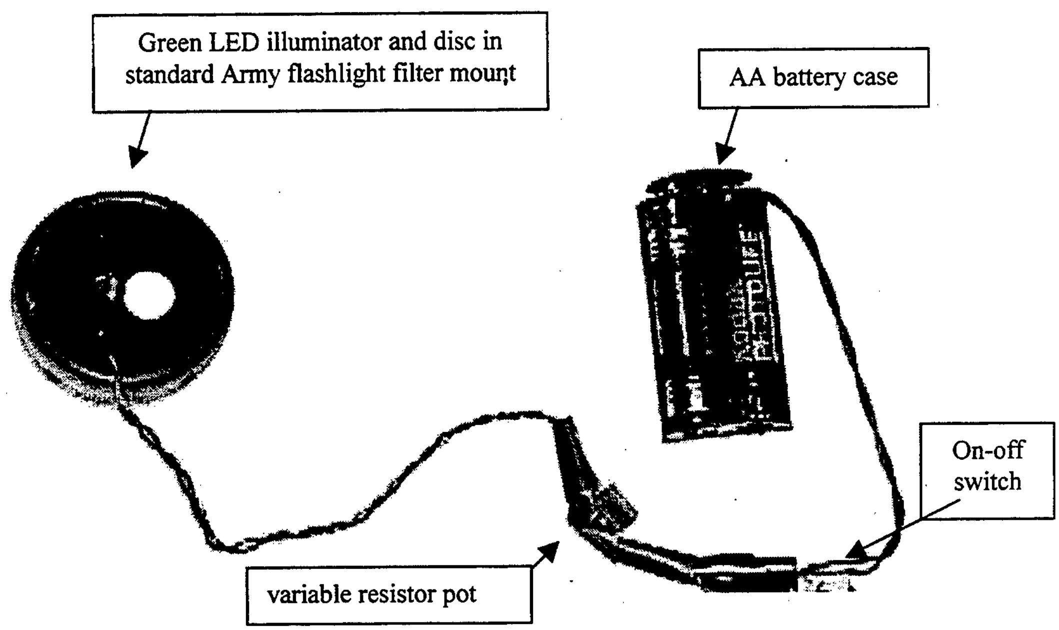

Figure 4. MNVD green-LED collimating device.

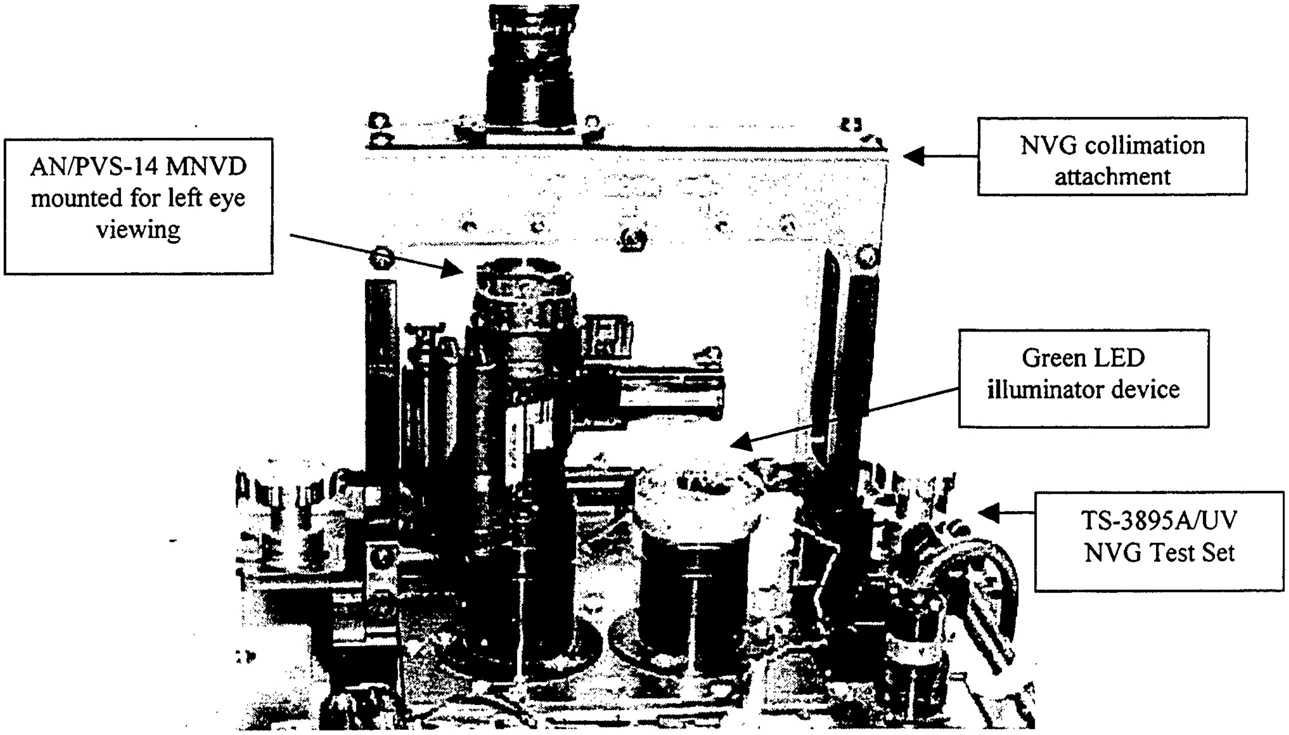

Figure 5. NVG test set with collimating attachment and MNVD LED illuminator.

The AN/PVS-14 MNVD comes with a pinhole cover for the objective lens. The pinhole cover permits the MNVD to be used under typical room illumination without damage to the intensifier tube. This pinhole cover is easy to remove, but cannot be quickly replaced over the objective lens. We replaced the pinhole cover with a spring-loaded flip-up riflescope cover. The window for the riflescope cover was made opaque using flat-black paint and a 4-mm aperture was drilled (Figure 2).

To determine the manual gain adjustment position, a yellow mark was placed on the front of the manual adjustment knob corresponding to the 12 o'clock position with the gain at the lowest point. Turning the knob clockwise as viewed by the other pilot increased the gain to a maximum at the 10 o'clock position. The safety pilot estimated the position of the manual gain knob set by the evaluating pilot by looking directly at the other pilot when the aircraft was on the ground, as requested by the investigator.

<u>AN/AVS-6(V)1 ANVIS</u> (UH-60 pilots only)

The MNVD was compared to the standard 15-mm eyepiece OMNI II ANVIS used for training at Fort Rucker, AL. Two sets of ANVIS were randomly selected from Lowe Army Helipad (AHP) for this evaluation. The high and low light resolutions were measured by the primary author using the TS-4348/UV Test Set, Electronic Systems (Tables 1a and 1b).

Table 1a.
Resolution AN/AVS-6 standard ANVIS - unit labeled #52.

	Left Tube		Right Tube	
	Air Force Tri-bar Pattern	Equivalent	Air Force Tri-bar Pattern	Equivalent
Light Level	Group, Element	Snellen Resolution	Group, Element	Snellen Resolution
High	4, 4	20/35	4, 3	20/40
Low	2, 6	20/112	2, 6	20/112

Table 1b.
Resolution AN/AVS-6 standard ANVIS - unit labeled #123A.

	Left Tube		Right Tube	
	Air Force Tri-bar Pattern	Equivalent	Air Force Tri-bar Pattern	Equivalent
Light Level	Group, Element	Snellen Resolution	Group, Element	Snellen Resolution
High	4, 3	20/40	4, 4	20/35
Low	2, 6	20/112	2, 6	20/112

AN/AVS-6(V)1A and ANVIS-9 (UH-60 pilots only)

After the UH-60 pilots had completed comparison of the PVS-14 to the standard ANVIS under high and low lighting conditions, they were permitted to use OMNI IV binocular ANVIS on the flight from the stage field back to Cairns Army Airfield (AAF). These NVGs are the most advanced fielded systems to date. The AN/AVS-6 (V)1A is used by the Army and the ANVIS-9 is used by the Air Force and Marines. High and low light resolutions were measured with the TS-4348/UV Test Set, Electronic Systems (Tables 2a and 2b). High and low light resolution measurements for the AN/PVS-14 are listed in Table 3.

Table 2a.
Resolution AN/AVS-6(V)1A OMNI IV ANVIS - unit labeled #2661.

	Left Tube		Right Tube	
	Air Force Tri-bar	Equivalent	Air Force Tri-bar	Equivalent
Light Level	Group, Element	Snellen	Group, Element	Snellen
High	5, 1	20/25	5, 1	20/25
Low	3, 2	20/89	3, 2	20/89

Table 2b.
Resolution AN/AVS-9 OMNI IV ANVIS - unit labeled or serial #CO1950.

	Left Tube		Right Tube	
	Air Force Tri-bar Pattern	Equivalent	Air Force Tri-bar Pattern	Equivalent
Light Level	Group, Element	Snellen Resolution	Group, Element	Snellen Resolution
High	4, 6	20/28	4, 6	20/28
Low	3, 1	20/100	3, 2	20/89

Table 3.
Resolution AN/PVS-14 OMNI IV MNVD - unit labeled or serial #0131.

	Single Tube on Left Side	
	Air Force Tri-bar Pattern	Equivalent
Light Level	Group, Element	Snellen Resolution
High	5, 1	20/25
Low	3, 2	20/89

The U.S. Army Aeromedical Research Laboratory (USAARL) had gained an understanding of the visual performance of the AN/PVS-14 previously with laboratory testing and from numerous observations at night in various military helicopters by the primary investigator during normal NVG training. Two USAARL pilots used the MNVD in the UH-60 simulator to assess the capabilities, and did not identify any potential flight difficulties or safety concerns that would prohibit actual flight evaluations with the MNVD compared to a typical flight with standard ANVIS.

This initial concept study of using the MNVD for pilotage employed a questionnaire and an audio tape recorder to obtain the opinions and perceptions of two experienced NVG pilots during various NVG flight maneuvers. The evaluation included flight under high and no moon conditions. The pilot, who was not using the PVS-14, acted as the safety pilot using standard binocular ANVIS. The standard maneuvers included for the evaluation were selected from the Aircrew Training Manual by the USAARL pilots.

UH-60 Blackhawk Assessment

Subjects

For this exploratory phase, two very experienced UH-60 NVG qualified pilots volunteered to evaluate the single tube AN/PVS-14 for pilotage. Both pilots had current Class II flight physicals. The USAARL pilot had 1650 and the Directorate of Evaluation and Standardization (DES) pilot had 800 NVG hours. Two aircrew members were seated in the rear on each side of the aircraft to assist the pilots for aircraft collision avoidance and terrain clearance.

Procedures

The participants were briefed on the purpose, procedures, content of the questionnaire, flight maneuvers, emergency procedures, and their individual rights for this evaluation. Participants signed volunteer consent forms verifying their informed consent. The two evaluating NVG pilots were given a laboratory demonstration of the MNVD to familiarize them with the adjustments with emphasis on the manual gain control adjustment effects. The pilots then used the MNVD in an UH-60 simulator for an hour under high and low night lighting conditions. During the flight evaluation, the safety pilot cued the evaluating pilot on the sequence of flight maneuvers and performed navigational assistance. See Appendix A for the volunteer consent form.

The USAARL UH-60 aircraft was used for the initial MNVD evaluations in this phase. The evaluators recorded their subjective impressions with a written questionnaire and with an audio tape recorder to compare different models of ANVIS and the MNVD for specific flight maneuvers. These assessments were conducted 16 September 1999 during a high moon condition (43% moon) and under starlight after moonset on the same date. The time for each evaluation for each goggle type and for each night illumination condition was approximately 45 minutes.

Experimental design

This was a concept, exploratory, and feasibility study conducted primarily to understand the variables that could affect the use of the MNVD, and to identify the limitations and advantages of the monocular high performance NVD compared to the presently fielded binocular ANVIS. The small sample size (two UH-60 pilots and two AH-64 pilots) will not provide for any valid

statistical analysis. Some of the potential variables or factors that could affect this subjective assessment are the following: (1) eye and seat configuration, i.e., right seat with left eye or right eye use; (2) ambient illuminations, e.g. high and low, and possibly weather effects; (3) flight tasks, i.e., landing, hovering, confine area, etc.; (4) eyepiece diopter focus; (5) manual gain positions for the MNVD; and (6) type of NVG compared with, i.e., 15-mm or 25-mm eyepiece ANVIS-6, ANVIS-6(V)1A, or ANVIS-9.

No attempt was made to balance or randomize the potential variables during the concept evaluation. For this first evaluation, the MNVD was mounted for left eye viewing; the pilots flew in either the right or left seat in the UH-60, without switching during the assessment; the eyepiece diopter focus was restricted to no more than -0.37 diopter of minus power by the eyepiece ring; the high and low night ambient illumination occurred in the same night and flight for the UH-60 assessment; and the pilots were allowed to adjust the manual gain of the PVS-14 for maximum performance or preference during any phase of the evaluation. The two NVGs evaluated and ranked for this phase were the 15-mm AN/AVS-6 and the AN/PVS-14 MNVD in the UH-60 (Table 4).

Table 4.
Sequence and flight maneuvers for UH-60 evaluation:

High Moon condition: 1. Mount/Adjust NVD's 2. Takeoff from Cairns AAF, Fort Rucker, AL; time 16 Sep 99, 1945 hours 3. Land at Highfalls (VMC approach to the ground) 4. Anti-collision light- Off, Position lights- Dim 5. Hovering Maneuvers: 1) 10' stationary (takeoff and landing) 2) 10' forward hover 3) 10' sideward hover 4) 360 degree turn @ 10' about the nose 5) 360 degree turn @ 10' about the tail 6) Masking/Unmasking 6. Terrain flight deceleration down runway to a specific point up to 3 times 7. Closed traffic (Roll-on landing) 8. Closed traffic (Steep approach to the ground) 9. Slopes 10. Takeoff to start point of low level Rte 144; Anti-collision light- On, Position lights- Bright 11. Low level flight Rte 144 12. Return to Highfalls a. Exchange NVD's b. Repeat sequence #'s4-12 13. Navigate to Florala Airport (2157 hours) for refueling, debriefing, and wait for moon to set. 14. Navigate back to Highfalls (2305) and Repeat sequence #'s 4-12 for no moon condition.

Note: The above listed tasks are flight maneuvers that are required to be performed by most qualified Army aviators. The tasks are described in Headquarters, Department of the Army Training Circular (TC) 1-212, Aircrew Training Manual, Utility Helicopter, UH-60/EH-60.

Results

Since only two UH-60 pilots participated in this initial concept evaluation, the results for the AN/PVS-14 MNVD with each pilot under high and low illumination are shown from each questionnaire as provided to each participant. The questions or requested information on the questionnaire were numbered for reference and clarity during the pilot briefings. The identities of the pilots are coded in bold print as pilot **A** and pilot **B**.

High ambient light evaluation questionnaire

1. Aircraft Type *UH-60A*

2. Goggle # (AN/PVS-14 w/o minus blue filter)

3. Flight #1 Sequence #1- high moon illumination

4. Approximate number of NVG hours: **A**: 1600. **B**: 800. ANVIS hours: **A**: 1500. **B**: 700

5. Seat side: (**A**: Left) (**B**: Right) Eye mounting for AN/PVS-14: (Left for **A & B**)

6. Helmet types: **A**: SPH-4B **B**: HGU-56/P Helmet Sizes: **A**: Reg. **B**: Med
   Counter weight: **A**: No. **B**: Yes

7. Percent Moon Illum: 43% Cloud cover: Scattered

8. How would you compare this goggle with a typical issued OMNI II, ANVIS?
   Rank your response using the following code:

1	2	3	4	5
much better	slightly better	same	slightly worse	much worse

pilot ID	A / B		A / B
Depth perception	4 / 4	Focus adjustments	2 / 3
Distortion	3 / 3	Mechanical adjustments	4 / 4 (tilt)
Resolution	3 / 4	Tube brightness	3 / 3
Scintillations (noise)	3 / 3	Low light gain	2 / 1
weight	2 / 2	center of gravity	2 / 3
NVG Field of view	4 / 4	Vision *Outside* cockpit	4 / 4
Unaided Field of view	2 / 1	Vision *Inside* cockpit	2 / 1
Manual gain (MNVD)	1 / 2	Headache or Eyestrain	3 / 4

9. Eyepiece diopter **A**: -0.25. **B**: +0.25 (Left) Eye **A & B** Sighting eye (Rt both **A & B**)

10. Beginning manual gain setting: **A**: 6 o'clock; **B**: 3 o'clock.
    Ending gain setting: **A**: 6 o'clock; **B**: 6 o'clock. Number of times adjusted: **A**: 0; **B**: 3.
    * Note- lowest gain setting is at 12 o'clock and clockwise rotation increases the gain to a maximum at the 10 o'clock position.

High ambient light evaluation questionnaire (continued)

11. Compared to a typical ANVIS, did you notice any difference with your unaided vision with this goggle when viewing either the instruments or outside the cockpit ?

(Yes) (No) ; If yes, identify whether you were looking inside and/or outside and describe.

A: (Yes) I saw much more of the cockpit.

B: (Yes) Excellent unobstructed view of the cockpit instruments. Much better unaided outside vision.

12. Did you notice any retinal rivalry when viewing *outside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

A & B (No)

13. Did you notice any retinal rivalry when viewing *inside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

A&B (No)

14. Did you find any maneuvers or procedures more difficult with the MNVD? (Yes) (No). If "Yes," list maneuvers. **A**: Roll-on landings, slopes, hover about the tail. **B**: Out of ground effect and hover about the tail.

15. Did you find any maneuvers or procedures easier with the MNVD? (Yes) (No). If "Yes" list maneuvers. **A**: cruise. **B**: None

16. Could this NVG (AN/PVS-14) (ANVIS-9) (NA) be mixed in the same cockpit with a standard ANVIS without affecting flight safety? (Yes) (No). If "No", explain.

A&B: (Yes)

17. Were the duration and conditions of this flight adequate to evaluate this goggle?

(Yes) (No) If no, how much additional time and/or what type flight conditions would you recommend? **A**: (Yes). **B**: (No) 5 hrs.

18. List any features of this goggle that was not included on this questionnaire that are better than a typical issued ANVIS. **A&B**: None

19. List any features of this goggle that was not included on this questionnaire that are worse than a typical issued ANVIS. **A&B**: None

20. Did you notice anything about the goggle being evaluated that you would recommend restricting its use by either NVG students or NVG qualified pilots? (Yes) (No) ; If yes, please explain.

A&B: (No)

Low ambient light evaluation questionnaire

Note: The low ambient light evaluation occurred on the same night as the high ambient light evaluation. The questions and requested information that were common to both questionnaires were removed in the results for the following assessments.

3. Flight #1 Sequence #2- low light

7. (night) Percent Moon Illum: None (moon set at 20:43 hours) Cloud cover: (scattered)

8. How would you compare this goggle with a typical issued OMNI II, ANVIS?
Rank your response using the following code:

1	**2**	**3**	**4**	**5**
much better	slightly better	same	slightly worse	much worse

pilot ID	**A / B**		**A / B**	
Depth perception	5 / 5	Focus adjustments	3 / 3	
Distortion	3 / 5	Mechanical adjustments	2 / 4	(tilt)
Resolution	4 / 5	Tube brightness	5 / 3	
Scintillations (noise)	4 / 3	Low light gain	4 / 3	
weight	2 / 2	center of gravity	2 / 2	
NVG Field of view	4 / 4	Vision *Outside* cockpit	4 / 5	
Unaided Field of view	2 / 1	Vision *Inside* cockpit	2 / 1	
Manual gain (MNVD)	2 / 3	Headache or Eyestrain	4 / 4	

9. Eyepiece diopter **A**: -0.25. **B**: +0.25 (Left) Eye **A & B** Sighting eye: (Rt both **A & B**)

10. Beginning manual gain setting: **A**: 10 o'clock; **B**: 10 o'clock.
Ending gain setting: **A**: 10 o'clock; **B**: 10 o'clock. Number of times adjusted: **A**: 0; **B**: 4.

11. Compared to a typical ANVIS, did you notice any difference with your unaided vision with this goggle when viewing either the instruments or outside the cockpit ?
(Yes) (No) ; If yes, identify whether you were looking inside and/or outside and describe.
A: (Yes) More unaided vision inside cockpit, less FOV outside.
B: (Yes) Much better view of cockpit instruments and controls. Outside viewing included color vision, but was not overly beneficial.

12. Did you notice any retinal rivalry when viewing *outside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.
A & B: (No)

Low ambient light evaluation questionnaire (continued)

13. Did you notice any retinal rivalry when viewing *inside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

A: (Yes) The gain on the aided eye was increaed to max. However, the retinal rivalry with the unaided eye decreased overall resolution.

B: (No)

14. Did you find any maneuvers or procedures more difficult with the MNVD? (Yes) (No). If "Yes," list maneuvers. **A**: Hovering maneuvers, terrain flight decel, Roll-on landings. **B**: Out of ground effect (OGE) hover, hover about the tail, roll-on landing, steep approach.

15. Did you find any maneuvers or procedures easier with the MNVD? (Yes) (No). If "Yes" list maneuvers. **A & B**: None

16. Could this NVG (AN/PVS-14) (ANVIS-9) (NA) be mixed in the same cockpit with a standard ANVIS without affecting flight safety? (Yes) (No). If "No", explain.

A&B: (Yes)

17. Were the duration and conditions of this flight adequate to evaluate this goggle? (Yes) (No) If no, how much additional time and/or what type flight conditions would you recommend? **A & B**: (Yes)

18. List any features of this goggle that was not included on this questionnaire that are better than a typical issued ANVIS. **A&B**: None

19. List any features of this goggle that was not included on this questionnaire that are worse than a typical issued ANVIS. **A&B**: None

20. Did you notice anything about the goggle being evaluated that you would recommend restricting its use by either NVG students or NVG qualified pilots? (Yes) (No) ; If yes, please explain. **A&B**: (No)

21. Complete after the 3rd evaluation on this flight- Which of the three goggles evaluated do you prefer? (AN/PVS-14) (AN/AVS-6, 15mm) (AN/AVS-9, 25mm). Give the primary reason(s) for your preference.

A&B: (ANVIS-9, 25mm). **A**: Better acuity, brightness. **B**: These goggles provided the best outside resolution and depth perception in low light conditions and still allowed easy viewing of cockpit instruments and controls.

Low ambient light evaluation questionnaire (continued)

22. After you have evaluated the NVG types, rank your order of preference with "1" being the most preferred and "3" the least.

	A / B
AN/AVS-6, 15 mm	2 / 2
ANVIS-9	1 / 1
AN/PVS-14	3 / 3

23. After the last evaluation, estimate how many hours (use 1/4 hour intervals) of AN/PVS-14 experience you have by category:

A: 2 hours simulator flight; 2 1/4 hours actual flight.

B: 1.1 hours simulator flight; 2.0 hours actual flight.

Comments: **A**: I really missed the image sharpness I usually experience with 6's or 9's under the low light conditions. The outside images had a blurry character. I really like the 14's during high light conditions, particularly in urban areas. During the low light conditions, I noticed a significant reduction in depth perception. I did not feel that I could increase the gain enough to match the tube brightness of the 9's. The absence of the minus blue filter was distracting. (Note: Since the evaluation in the UH-60, a Class A equivalent minus blue filter was added using the LIF adapter mounting.)

B: The advantage of having color vision and unaided field of view with the AN/PVS-14 does not off-set the benefits of the ANVIS-9.

From the comments by the two UH-60 pilots, a follow-up questionnaire was used to obtain additional information.

AN/PVS-14 study follow-up questions

Subject IDs: **A & B**:

1. Compare the AN/PVS-14 to AN/PVS-5. Which would you prefer?
   - **A**: Low light conditions- I would pick 5's. High light conditions/ urban areas- I would pick 14's.
   - **B**: AN/PVS-14.

2. Would mounting the PVS-14 on the right eye make any difference in your responses?
   - **A**: No- Prefer mounting on the outside eye.
   - **B**: Possible.

AN/PVS-14 study follow-up questions (continued)

3. Would different type aircraft make any difference?
   A: No.
   B: Don't know.

4. If PVS-14 image was black and white instead of green, would this help?
   A: No.
   B: Don't know.

5. Would the minus blue filter in the PVS-14 make any difference?
   A: Yes, due to existing NVG lighting in cockpits.
   B: Yes- Noted with outside vision during low light conditions.

6. What were the best maneuvers for evaluating the single tube PVS-14?
   A: Hovering turns, roll-on landings.
   B: Roll-on landings, OGE, and terrain flight.

7. What maneuvers did not make any difference in the evaluation?
   A: Cruise flight (terrain flight and greater).
   B: All the others.

8. Did the simulator help prepare you for the flight evaluation of the PVS-14?
   A: Yes, Definitely.
   B: Yes.

9. Could the simulator be used for the evaluation for issues such as which eye for which seat, retinal rivalry, depth perception, gain control setting, etc.
   A: No, due to graphics quality.
   B: No.

Discussion

The results from this concept study of using the modified monocular AN/PVS-14 for helicopter flight suggest that a standard (OMNI II) or binocular ANVIS would be preferred over a monocular high resolution and gain device. This opinion was shared for the two UH-60 evaluating pilots. The initial flight responses with the MNVD under high ambient illumination were ranked similar to the current ANVIS. However, when the night illumination was lower without any moon light, the pilots reported much more difficulty in depth perception and resolution using the single tube AN/PVS-14 even though the low light resolution and system gain were higher than either tube in the standard ANVIS. In addition to the comments by the pilots about conflict between the aided and unaided vision at the lower ambient illumination, there also

appears to be some binocular summing of the illumination from the ANVIS images that was not quantified.

AH-64 Apache assessment

COL James Mowery, DES, U.S. Army Aviation Center (USAAVNC), Fort Rucker, AL, requested assistance from USAARL to evaluate the potential concept of using the AN/PVS-14 MNVD in the AH-64A to improve early obstacle detection and avoidance, as well as improving target detection. See Appendix C for Memorandum of Intent to the USAAVNC Commanding General. The AH-64 concept evaluation would be slightly different than the evaluation by the UH-60 pilots. Apache pilots normally fly at night with a monocular helmet display unit before the right eye. The head coupled sensor is called the Pilot's Night Vision System, which is a forward looking infrared device. It is located on the nose of the aircraft, and is view with the HDU. The HDU also provides flight and weapon symbology with or without the FLIR imagery. The Apache copilot/gunners in the front seat have been authorized to use the ANVIS as a compliment to the FLIR since 1987. However, when the binocular ANVIS is used, the copilot/gunner does not have either the FLIR imagery or the flight/weapon symbology. The intent of this concept evaluation was to determine any possible advantages of using the AN/PVS-14 MNVD in front of the left eye and the HDU with symbology and/or FLIR imagery in front of the right eye (Figure 6).

Figure 6. HDU and MNVD mounted on IHADSS helmet.

Subjects

DES provided two AH-64 pilots for this evaluation. The pilots were briefed on the project and signed volunteer consent forms which described the objectives of the project, potential risks, and the right to terminate participation without any prejudice.

Procedures

The two pilots were given a laboratory demonstration and the opportunity to practice with the mechanical adjustments of the MNVD. One of the pilots used the USAARL UH-60 simulator and the other pilot used the AH-64 Combat Mission Simulator (CMS) to become familiar with the MNVD using the left eye. The MNVD was used in the front seat of the Apache with the back seat pilot acting as the safety pilot using the FLIR. The list of maneuvers and sequence from the UH-60 assessments were provided as a guide, but the individual flight maneuvers and sequences were determined by each evaluating pilot using crew coordination with the safety pilot. The pilots and the researcher expanded the original questionnaire to cover the use of the HDU and MNVD combination. Flights were conducted under high (95% and 50% moon illumination) and no moon conditions for both pilots during four nights. Flight numbers 1 and 3 were under a no moon condition and flight numbers 2 and 4 were with high moon illumination (50% and 98%, respectively).

During the UH-60 flight assessment, both pilots indicated that the cockpit instruments affected outside viewing with the MNVD due to the absence of the minus-blue cut-off filter that is standard in all Army ANVIS. Therefore, minus-blue (red) glass filters with both Class A (625 nanometer cut-off) and Class B (665 nanometer cut-off) were ordered to mount in the Light Interference Filter (LIF) holder. The Class A minus-blue filter was used for the AH-64 assessments. However, the Apache pilots indicated that they turned the cockpit lights off in the front seat when using image intensifiers. Figure 7 shows the minus-blue filters mounted in the LIF housing and on the MNVD objective lens.

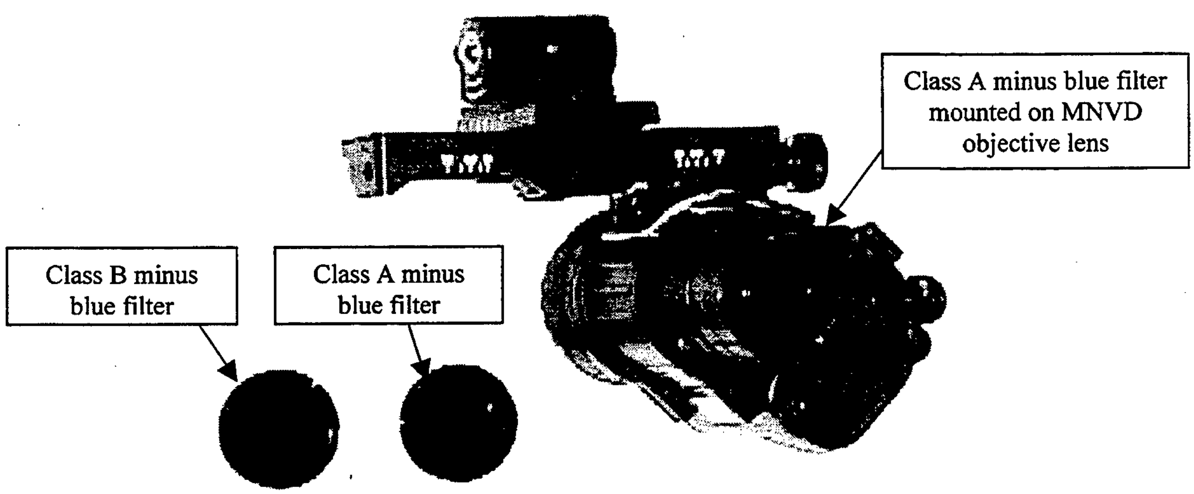

Figure 7. Minus-blue filters mounted in LIF holders.

Results

With only two pilots for the concept evaluation, the individual results are reported with the pilots identities labeled in bold for ease of reading as **S** and **T**.

High ambient light evaluation questionnaire (MNVD using only symbology with HDU)

1. Aircraft Type AH-64A

2. Goggle # (AN/PVS-14 with minus blue filter equivalent)

3. Flights: **S**: #4. **T**: #2 Sequence: High moon illumination

4. Approximate number of NVG hours : **S**: 159. **T**: 400. ANVIS hours_**S**: 87. **T**: 200. PNVS hours: **S**: 1085. **T**: 1500.

5. Seat location: **S & T**: (front) Eye mounting for AN/PVS-14 (Left for **S & T**)

6. Helmet types: **S & T**: IHADSS. Helmet Size: **S & T**: Large. Counter weight: **S & T**: Yes

7. Percent Moon Illum: **S**: 98%. **T**: 50% Cloud cover: **S**: Thin scattered. **T**: None

8. How would you compare this goggle with a typical issued OMNI II, ANVIS?
   Rank your response using the following code:

1	**2**	**3**	**4**	**5**
much better	slightly better	same	slightly worse	much worse

pilot ID	**S / T**		**S / T**
Depth perception	2 / 2	Focus adjustments	3 / 3
Distortion	1 / 2	Mechanical adjustments	4 / 4
Resolution	1 / 2	Tube brightness	2 / 2
Scintillations (noise)	2 / 2	Low light gain	2 / 2
weight	1 / 3	center of gravity	3 / 4
NVG Field of view	4 / 3	Vision *Outside* cockpit	4 / 3
Unaided Field of view	4 / 2	Vision *Inside* cockpit	4 / 2
Manual gain (MNVD)	2 / 2	Headache or Eyestrain	4 / 3

9. Eyepiece diopter **S**: unknown. **T**: +0.50 diopters Sighting eye (Lt both **S & T**)

10. Beginning manual gain setting: **S & T**: full bright (10 o'clock position)
    Ending gain setting: **S & T**: full bright. Number of times adjusted: **S**: 2; **T**: 3-5.

High ambient light evaluation questionnaire (MNVD using only symbology with HDU) (continued)

11. Compared to a typical ANVIS, did you notice any difference with your unaided vision with this goggle when viewing either the instruments or outside the cockpit ?

(Yes) (No) ; If yes, identify whether you were looking inside and/or outside and describe.

S: (Yes) The most noticeable difference was looking outside. This was due to the HDU on the right side obstructing vision.

T: (No).

12. Did you notice any retinal rivalry when viewing *outside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S & T (Yes). **S**: Very little rivalry, but did occur several times due to the brightness of the HDU symbology versus the tube (MNVD) brightness. HDU was brighter and would increase rivalry. **T**: For the first few minutes. Once use to MNVD in left eye and HDU in right eye, no problem.

13. Did you notice any retinal rivalry when viewing *inside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S & T (No)

14. Did you find any maneuvers or procedures more difficult with the MNVD? (Yes) (No). If "Yes," list maneuvers. **S**: (Yes). Maneuvers in which the nose of the a/c comes up, severly degrades forward visibility for MNVD. **T**: (No).

15. Did you find any maneuvers or procedures easier with the MNVD? (Yes) (No). If "Yes," list maneuvers. **S**: (Yes). Terrain flight and hovering tasks were aided by the higher resolution of the MNVD versus the FLIR. **T**: (No)

16. Did the symbology from the HDU align within the MNVD field of view? (Yes) (No). **S & T**: (No). Appeared higher in the field of view.

17. Did the symbology seem to float within the MNVD field of view? (Yes) (No). **S & T**: (No).

18. Did the MNVD enhance enroute navigation and aid in obstacle detection/avoidance? (Yes) (No) If "Yes," describe the enhancement as compared to current ANVIS 6 operations.

S: (Yes). At NOE altitudes, it provided a good resolution of scene being viewed

T: (No).

19. Did the MNVD enhance target detection? (Yes) (No) Give details regarding your answer.

S: (Yes). If the target was illuminated with any source of light, it was easily detected. Long range (2000 meters and beyond) without light source were undetectable.

T: (No).

High ambient light evaluation questionnaire (MNVD using only symbology with HDU) (continued)

12. If MNVD was used to detect target, what was the TADS ability to slave to target? List which field of view (FOV) was the best in regard to "Boresight Handover" of ANVIS image to FLIR image.

S: TADS ability to slave was good, if flying with symbology only with MNVD and the TADS. FLIR on the Copilot/gunner (CPG) Fire Control Panel systems switch placed in the OFF or FLIR OFF position would not allow use of TADS FLIR before placing switch to TADS and allowing FLIR to cool down (approx 10-15 minutes). I had no problem with initial acquisition in the wide field of view (FOV) with moving targets. With stationary targets, it was possible in medium FOV.

T: Did not have time to evaluate.

High ambient light evaluation questionnaire (MNVD using FLIR with HDU)

S & T: Did not use FLIR and MNVD under high moon illumination due to time constraints.

Low ambient light evaluation questionnaire (MNVD using only symbology with HDU)

3. Flight number: **S**: #1. **T**: #3 Sequence: Low illumination (no moon)

7. Percent Moon Illum: **S**: 01%. **T**: 00% Cloud cover: **S**: Clear. **T**: None

8. How would you compare this goggle with a typical issued OMNI II, ANVIS?
Rank your response using the following code:

1	**2**	**3**	**4**	**5**
much better	slightly better	same	slightly worse	much worse

pilot ID	**S / T**		**S / T**
Depth perception	2 / 2	Focus adjustments	3 / 3
Distortion	2 / 2	Mechanical adjustments	4 / 3
Resolution	1 / 2	Tube brightness	2 / 3
Scintillations (noise)	2 / 2	Low light gain	1 / 2
weight	1 / 3	center of gravity	3 / 4
NVG Field of view	4 / 3	Vision *Outside* cockpit	4 / 2
Unaided Field of view	4 / 2	Vision *Inside* cockpit	4 / 2
Manual gain (MNVD)	2 / 3	Headache or Eyestrain	5 / 5*

* Left eye strain was evident during this flight. Focus was set correctly. I believe the strain was due to the difference in brightness between the two displays. The HDU display is brighter and a different shade of green than the MNVD.

9. Eyepiece diopter **S & T**: +0.50 diopters Sighting eye (Lt both **S & T**)

10. Beginning manual gain setting: **S & T**: full bright
Ending gain setting: **S & T**: full bright. Number of times adjusted: **S**: 5; **T**: 1-3.
(Note that evaluator **S** recorded "Same" for high and no moon responses for these questions.

11. Compared to a typical ANVIS, did you notice any difference with your unaided vision with this goggle when viewing either the instruments or outside the cockpit ?
(Yes) (No) ; If yes, identify whether you were looking inside and/or outside and describe.
S: (Yes) The most noticeable difference was looking outside. This was due to the HDU on the right side obstructing vision.
T: (No).

Low ambient light evaluation questionnaire (MNVD using only symbology with HDU) (continued)

12. Did you notice any retinal rivalry when viewing *outside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S (Yes). **S**: Very little rivalry, but did occur several times due to the brightness of the HDU symbology versus the tube (MNVD) brightness. HDU was brighter and would increase rivalry.

T: No

13. Did you notice any retinal rivalry when viewing *inside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S & T (No)

14. Did you find any maneuvers or procedures more difficult with the MNVD? (Yes) (No). If "Yes," list maneuvers. **S**: (Yes). Maneuvers in which the nose of the a/c comes up, severely degrades forward visibility for MNVD. **T**: No more than with AN/AVS-6.

15. Did you find any maneuvers or procedures easier with the MNVD? (Yes) (No). If "Yes" list maneuvers. **S**: (Yes). Terrain flight and hovering tasks were aided by the higher resolution of the MNVD versus the FLIR. **T**: (No)

16. Did the symbology from the HDU align within the MNVD field of view? (Yes) (No).

S & T: (No). Appeared higher in the field of view.

17. Did the symbology seem to float within the MNVD field of view? (Yes) (No). **S & T**: (No).

18. Did the MNVD enhance enroute navigation and aid in obstacle detection/avoidance? (Yes) (No) If "Yes" describe the enhancement as compared to current ANVIS 6 operations.

S: (Yes). At NOE altitudes. However, with low illumination, the higher the A/C was from the terrain, the worse the image.

T: (No).

19. Did the MNVD enhance target detection? (Yes) (No) Give details regarding your answer.

S: (Yes). If the target was illuminated with any source of light, it was easily detected. Long range (2000 meters and beyond) without a light source, targets were undetectable.

T: (Yes). As long as the target area had lights, it was easier to acquire than with NVS.

Low ambient light evaluation questionnaire (MNVD using only symbology with HDU) (continued)

20. If MNVD was used to detect target, what was the TADS ability to slave to target? List which field of view (FOV) was the best in regard to "Boresight Handover" of ANVIS image to FLIR image.

S: TADS ability to slave was good, if flying with symbology only with MNVD and the TADS. FLIR on the Copilot/gunner (CPG) Fire Control Panel systems switch placed in the OFF or FLIR OFF position would not allow use of TADS FLIR before placing switch to TADS and allowing FLIR to cool down (approx 10-15 minutes). I had no problem with initial acquisition in the wide field of view (FOV) with moving targets. With stationary targets, it was possible in medium FOV.

T: Finding targts with MNVD and slaving with TADS was no problem. TADS was slaved to gunner's helmet sight (GHS) so it was always looking in the same direction as MNVD. Medium FOV was the best FOV to first acquire targets then zoom in from there.

Low ambient illumination questionnaire (MNVD using FLIR with HDU)

1. Beginning manual gain setting: **S**: full. **T**: no entry. Ending gain setting: **S**: full. **T**: no entry. Number of times adjusted: **S**: 2. **T**: no entry.

2. While using the MNVD with HDU, did you have adequate **unaided** vision when viewing either the instruments or outside the cockpit?

S: (No). Inside the cockpit was adequate but outside was restricted due to HDU mounting.

T: no entry.

3. Did you notice any retinal rivalry, MNVD and HDU images, when viewing *outside* the cockpit? If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S: (Yes). Initially, I rode along with the safety pilot as he flew the aircraft. This was due to the disorientation present when using both systems. I felt nausea immediately, but after riding along, I was able to combat the rivalry and associated nausea by closing the eye of the sustem not being used. I flew the aircraft through a series of maneuvers with no evident safety concerns, but was constantly switching eyes or systems to gain information most important for that phase of flight.

T: (Yes). Could not fly due to the pictures not overlapping and being in different formats. Caused nausea.

4. If you had image rivalry between the MNVD intensified and the HDU thermal images, could you control it? (Yes) (No).

S: (Yes). By closing one eye on the system not being used for flight information.

T: (No). Only by closing one eye.

5. Did you notice any retinal rivalry or difficulty when viewing *inside* the cockpit? (Yes) (No). If "Yes," describe the objects viewed when rivalry occurred and approximately the duration.

S: (Yes). Same application of closing one eye, usually the HDU or right eye would allow inside the cockpit viewing.

T: Did not fly with FLIR due to question #3.

6. Did you find any maneuvers or procedures difficult when using both the MNVD and FLIR imagery simultaneously? (Yes) (No). If "Yes" list maneuvers.

S: (Yes). It was difficult for all maneuvers to simultaneously use both systems; switching eyes was the best method.

T: See #3.

Low ambient illumination questionnaire (MNVD using FLIR with HDU) (continued)

7. Did you find any maneuvers or procedures made easier when using both the MNVD and FLIR imagery simultaneously? (Yes) (No). If "Yes," list maneuvers.

S: (Yes). Any maneuver that MNVD could not see under the nose of the aircraft, the HDU FLIR could, so by switching eyes it made approaches or decelerative attitudes possible with a view of the upcoming terrain.

T: (Yes). Target identification and acquisition.

8. Did the MNVD enhance enroute navigation and aid in obstacle detection/avoidance? (Yes) (No). If "Yes," describe the enhancement as compared to current ANVIS 6 opertaions.

S: (Yes). You could use whichever system was providing the most content.

T: (No). See #3.

9. Did the MNVD enhance target detection? (Yes) (No). Give details regarding your answer.

S: (Yes). Same as MNVD only but there was no cool down period to wait on.

T: (Yes) See prior page.

10. If MNVD was used to detect target, what was the TADS ability to slave to target? List which field of view (FOV) was the best in regard to "Boresight Handover" of ANVIS image to FLIR image.

S: Moving targets had to be slaved to in wide FOV, stationary targets could be slaved to in medium FOV. The "Boresight Handover" was fairly aligned.

T: See prior page.

11. Did the FLIR imagery from the HUD align within the MNVD field of view? (Yes) (No).

S: (Yes). Pretty well; it wasn't exact but close enough to complete handover.

T: (No).

12. Did the imagery seem to float within the MNVD field of view? (Yes) (No). If "Yes", was the floating distracting? (Yes) (No) (NA).

S: (Yes). It happened several times during the use of both systems. The HDU FLIR was more dominant in my case. FLIR possibly due to the low illumination seemed to be the overriding sensor. The exception was NOE and hovering flight. MNVD had better resolution. The symbology appeared to be on both eyes or superimposed over the MNVD.

13. Did you find it easier to use (white) hot or (black) hot or (no difference) with the thermal image and the MNVD?

S: (No difference). If polarity was changed, it was changed at the same frequency as a normal NVS would have demonstrated. White or Black did not aide the MNVD in any way.

T: (No difference).

Low ambient illumination questionnaire (MNVD using FLIR with HDU) (continued)

14. Did you need to adjust brightness of IHADSS FLIR imagery different than normal when you used the MNVD? (Yes) (No).

S: (Yes). The brightness and contrast adjustment was driven down more than the normal grey scale for IHADSS.

T: Could not use.

15. Would you recommend using the MNVD with the HDU FLIR imagery simultaneously? (Yes) (No).

S: ? It depends on the aircrew experience level and the mission profile. If light discipline is poor for enemy, I would say "Yes," but you would have to switch eyes/systems.

T: Only for target acquisition.

16. Were the duration and conditions of this flight adequate to evaluate the MNVD with the HDU? (Yes) (No). If no, how much additional time and/or what type flight conditions would you recommend?

S: (Yes). Will just fly one more flight with high moon conditions.

T: (Yes).

17. List any features of using the MNVD with the HDU that was not included on this questionnaire that are better than using a typical issued ANVIS alone or HDU alone.

S: Rapid application of either system was possible, but would not work for everyone.

T: Only that you can fly NVG with symbology. If ANVIS 6 with symbology were available, it would be as beneficial as the AN/PVS-14.

18. List any features of using the MNVD and the HDU that was not included on this questionnaire that are worse than a typical issued ANVIS alone or HDU alone.

S: Rivalry and eyestrain were the worst side effects.

T: None.

19. Did you notice anything about the MNVD being evaluated that you would recommend restricting its use by either Apache students or Apache qualified pilots? (Yes) (No); If yes, please explain and list recommended restrictions.

S: (Yes). It would be overwhelming for students, but may not be a safety issue for qualifed pilots with training.

T: (Yes). Eye strain when used with HDU. Would much rather have two tubes with symbology.

Low ambient illumination questionnaire (MNVD using FLIR with HDU) (continued)

20. Under the conditions flown on this mission, rank the imaging system combination provided the best overall performance where 1 is best and 10 is worst.

	S / T
ANVIS alone	4 / 5
PNVS alone	3 / 3
MNVD alone	6 / 6
MNVD with Symbology	5 / 4
MNVD with FLIR	8 / 10

21. After the last evaluation, estimate how many hours (use 1/4 hour intervals) of AN/PVS-14 experience you have by category:

S: 1 3/4 hour simulator flight; 3 1/2 hours actual flight.

T: 2 hours simulator flight; 3 1/2 hours actual flight.

Discussion

Both pilots rated the MNVD favorably under high moon illumination compared to the standard ANVIS, and higher than the UH-60 pilots for specific characteristics such as resolution. However, after flying the MNVD under low light and with the HDU, both pilots preferred the standard ANVIS overall compared to the MNVD. Unlike the UH-60 pilots, the 12 percent combiner transmission of the HDU blocked the unaided right eye. The Apache pilots will normally have the left eye unobstructed when using the HDU with FLIR imagery at night. This would explain why they rated the unaided vision and unaided field of view less than with the standard ANVIS or the HDU alone.

The modified AN/PVS-14 MNVD was not rated equivalent to a standard ANVIS for pilotage by the Apache pilots. Although they noted the better resolution from the MNVD than is obtained with the FLIR, the pilots believed that a head-up display for the binocular ANVIS was a better solution. Luminance imbalance between the HDU with symbology only and MNVD was mentioned several times even though both devices have manual gain or brightness adjustment controls.

After the questionnaires had been completed, the two Apache pilots were asked how long it typically takes for a beginning Apache pilot to learn to use the monocular HDU, and if the monocular AN/PVS-14 would require a similar adjustment period. Their response was that the time to initially adjust to the monocular HDU for pilotage by students varied among individuals, but between 5 to 12 hours would be a typical value. They felt that the adjustment time to the MNVD would be less than the time to adjust to the HDU for NVG and IHADSS qualified pilots, and that additional time with the MNVD would probably not improve performance or comfort with the MNVD under starlight conditions.

Conclusion

The results from this concept study of using the modified monocular AN/PVS-14 for helicopter flight suggest that a standard (OMNI II) or binocular ANVIS would be preferred over a monocular high resolution and gain device. This opinion was unanimous among the four evaluating pilots. Although the scenario of the possible use of the MNVD during a civilian medical evacuation in an urban environment was not evaluated, the authors do not believe any further research in using a monocular image intensified system for helicopter pilotage would be beneficial at this time with the current technology.

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Abbreviations

AAF- Army Airfield

AHP- Army Helipad

ANVIS- Aviator's Night Vision Imaging System (AN/AVS-6)

CMS- Combat Mission Simulator (AH-64)

CPG- Copilot/Gunner in the AH-64

CRT- cathode ray tube

DES- Directorate of Evaluation and Standardization

FCU- Fire Control Panel

FOV- Field Of View

FLIR- Forward Looking Infrared

HDU- Helmet Display Unit

IHADSS- Integrated Helmet And Display Sighting System

IPD- Interpupillary Distance between the eyes

K W- Kiowa Warrior (OH-58D)

LIF- Light Interference Filter

MNVD- Monocular Night Vision Device

NA- Not Applicable

NOE- Nap Of the Earth

NVD- Night Vision Device

NVG- Night Vision Goggle

NVS- Night Vision Sensor

OMNI or OMNIBUS- A government procurement contract and specifications for military equipment. For ANVIS, there have been four procurement contracts: OMNI I, II, III, and IV.

PNVS- Pilot Night Vision System

TADS- Target Acquisition and Designation System

Tri-bar- Three-bar 1951 Air Force resolution chart

USAARL- U.S. Army Aeromedical Research Laboratory

USAAVNC- U.S. Army Aviation Center

VMC- Visual Meteorological Conditions which describes weather conditions where the visibility is sufficient to fly from references outside the cockpit as opposed to flying only with instruments.

Appendix A.

Volunteer consent form, part B.

PART B -- TO BE COMPLETED BY INVESTIGATOR

INSTRUCTIONS FOR ELEMENTS OF INFORMED CONSENT: *(Provide a detailed explanation in accordance with Appendix C, AR 40-38 or AR 70-25.)*

PURPOSE

The purpose of this study is to determine the feasibility to include advantages and disadvantages of using a monocular night vision device (MNVD), AN/PVS-14, for helicopter pilotage.

PROCEDURE

Prior to beginning the flight study, you will be briefed on the operation of the AN/PVS-14, given a demonstration in the laboratory under various light levels, and complete a simulator ride in the UH-60 simulator with the AN/PVS-14 MNVD. A list of the flight maneuvers and the general flight plan will be briefed prior to the simulator and actual NVG flight.

The time to complete this study is estimated at approximately 1 hour of ground time to include the briefing, laboratory demonstration and simulator ride; and 4 hours of flight time. You will evaluate the NVGs during approximately a two hour flight on two separate nights under starlight and with >50 percent moon illumination. Your evaluations will be completed using questionnaires and an audio recorder.

BENEFITS

You will receive no benefits for participating in this study.

RISKS

There are no additional risks associated with using standard issued U.S approved military equipment for the NVG evaluations with the ANVIS-6 and ANVIS-9. However, the risks from using an NVG with a single tube will be unknown until it is actually flown. Risks will be minimized by first using the MNVD in the simulator, by the evaluator satisfactorily performing less difficult flight tasks before more difficult tasks, and by using only an experienced NVG safety pilot who will be wearing binocular NVGs (ANVIS). When you are on the controls, if you experience any apprehension or are unsure of a critical parameter during a maneuver such as altitude, obstacle clearance distances or closure rates, immediately communicate with the safety pilot to include actions you will be taking, such as aborting the maneuver or transferring the controls. You may elect to simply observe the maneuver(s) with the safety pilot on the controls for your evaluations.

ADDITIONAL INFORMATION

You are encouraged to ask questions and make comments during the study. You may request breaks, transfer the controls, or quit at any time without any fear of retribution. You are not being compared to anyone else. All data and medical information obtained about you as an individual will be considered privileged and held in confidence. However, complete confidentiality cannot be promised, particularly if you are a military service member, because information bearing on your health may be required to be reported to appropriate medical or Command authorities. In addition, applicable regulations note the possibility the U.S. Army Medical Research and Materiel Command (USAMRMC) officials may inspect the records.

Appendix B.

Moon illumination, moon set time and moon altitudes on 16 September 1999.

16 September 99, Fort Rucker, AL, 43% moon illumination

Time:	Moon Altitude (degrees) & millilux from moon illumination		
1848	38	426 Lux	Sunset
1912	37	3 Lux	End Civil Twilight (ECT)
1940	34	9.3 mL	End Nautical Twilight (ENT)
2000	32	8.6 mL	
2020	29	7.8 mL	Low light by definition <30 degrees Alt.
2040	26	6.9 mL	
2100	23	6.0 mL	
2120	20	5.0 mL	
2211	12	2.2 mL	Low light by lux value
2220	10	2.0 mL	
2245	5	1.0 mL	
2317	0	0.0	Moon Set

Low illumination defined by ambient millilux (mL) is 2.2 mL, which occurs for 23 % moon illumination at 30 degrees altitude.

Appendix C.

Memorandum from DES to Commanding General.

ATZQ-ES

29 September 1999
CW4 Santini/bh/2532

MEMORANDUM FOR CG

SUBJECT: Memorandum of Intent

1. Purpose. To inform MG Jones, Commanding General, United States Aviation Center, of the Directorate of Evaluation and Standardization (DES), request to the U.S. Army Aeromedical Research Laboratory (USAARL), to design and conduct flight and physiological testing of the AN/PVS-14 MNVD.

2. Intent. For USAARL to provide the AN/PVS-14 MNVD system with test guidance and procedures to allow DES to conduct the flight and physiological testing within the AH-64A. The test will provide data regarding the feasibility of the single OMNI IV goggle tube application during simultaneous use of the AH-64A Target Acquisition Designation Sight (TADS) FLIR and the Helmet Display Unit (HDU). The enhancement of the AH-64A's aircraft/cockpit capabilities while conducting terrain flight should be improved for early obstacle detection and avoidance, as well as improving target detection.

3. Coordinating Instructions:

a. DES will provide a Subject Matter Expert (SME), aircraft, flight hours, and an additional safety pilot for conduct of ground and flight use of the AN/PVS-14 MNVD application.

b. Desired start date of ground and flight testing to begin 18 October 1999 and to conclude prior to 30 December 1999.

c. USAARL in coordination with Dr. Bill McLean will provide test guidance, procedures and equipment to DES SME for conducting flight-testing.

4. Points of Contact are CW4 Clay Santini, DES (5-2532), and Dr. Bill McLean, USAARL (5-6813).

For

JAMES L. MOWERY
Colonel, Aviation
Director of Evaluation
and Standardization

Appendix D.

Additional comments provided by one of the AH-64 Apache pilots.

ATZQ-ES

2 February 2000 [redacted]

MEMORANDUM FOR USAARL

SUBJECT: MNVD Flight Summary (AH-64A)

1. Summary. Coordination between Dr. Bill Mclean (USAARL), and [redacted] (DES), was made to ensure DES SME's received training on operation and characteristics of the AN/PVS-14 (MNVD). Several training flights were conducted in the AH-64A CMS to practice and evaluate the MNVD for operation in the aircraft. Aircraft Flights began 8 Nov, 1999 and concluded 20 Jan, 2000 (four flights in total). The Flights consisted of Low, Mid, and High Moon conditions to evaluate the different ambient light levels with performance of the MNVD. The MNVD was flown with simultaneous flight symbology and/or FLIR on the HDU. The following observations were concluded from this flights:

2. The best settings for flying with the MNVD and HDU was to place the Sight-Select Switch on the CPG FCP to NVS. System FLIR switch to FLIR OFF. This would allow the NVG presentation to be viewed by the left eye, and PNVS pilots flight symbology to be viewed without FLIR in the right eye. Using these positions made the brain perceive the flight symbology and NVG picture appear to be present in both eyes. However, this did cause eyestrain in the left eye on several occasions. This was probably due to the differences in brightness and color hue between the two displays. The HDU was brighter than the NVG picture, even after several attempts to adjust brightness and contrast. The biggest shortcoming from these settings was that the FLIR must be allowed to cool (approx. 10-12 minutes) prior to being employed.

3. Placing the Sight Select Switch in HMD position only allows "Gunners" symbology to be presented without attitude reference or velocity vector/acceleration cue. This symbology for flight is not sufficient for all crewmembers.

4. Several attempts to use PNVS FLIR with the MNVD were made, but only after flying as passenger to train the brain in the perception of the viewed scene. Each pilot flew the aircraft through a series of maneuvers safely but eventually succumbed to eyestrain and the onset of nausea. These feelings could be held off by closing the eye that was experiencing retinal rivalry. When only using the one eye for viewing and gathering flight information it enhanced the flight somewhat due to the availability of both scenes (NVG and FLIR). This switching of the eyes could be trained but would not present a viable option for the entire Apache community.

5. In conclusion, it was decided between [redacted] that if NVG operations were to continue to be a mode of flight utilized by the AH-64 community then the following might be addressed: Develop a HUD with AH-64 pilot flight symbology to be used with current generation ANVIS (like KW and UH-60). This would still allow use of the TADS for targeting with FLIR and flight capabilities with ANVIS.

[redacted]
CW4, USA
DES AH-64A SP